Working Memory Workshop

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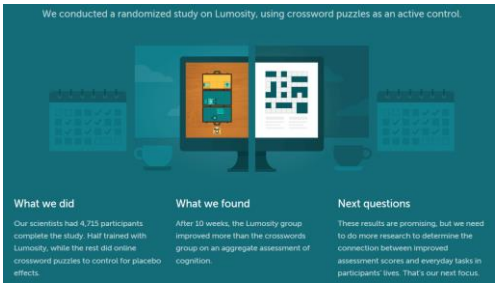
Aims of workshop

For participants to:

- understand working memory systems relevant to language processing
- understand the implications of poor working memory for assessment /intervention
- have hands-on experience testing working memory
- understand the evidence base around working memory training programmes
- consider application to clients



Cognitive training programmes are now multi-million dollar businesses

It is important for SLTs to understand what WM is and how it interfaces with language so we can:

- Inform your recommendations for working memory assessment / intervention
- Give advice to parents of children who have limited WM spans.

Memory and Language

How do you learn language without a good memory?

Much research done on the interaction of memory systems and language processing
Poor working memory is a current causal theory of SLI (Bishop, 2006)
Poor working memory is commonly associated with specific learning disabilities e.g. dyslexia (Dawe, Leitao, Claessen & Nayton, 2015)

Short term memory

- Up to 20 seconds (depending)
- Limited capacity – 4 chunks
- Storage, rehearsal and retrieval
- Decay – mitigated by rehearsal
- Measured by simple span tasks
- Examples – phone numbers, exact sentence someone said, how to spell a new word, how to say a new word

Baddeley (2000)

Long term memory

- Unlimited capacity
- Gateway to LTM is STM
- Storage and retrieval
- Cue dependent – can access information given right cues
- Can be divided into two areas
  - Declarative e.g. vocabulary, faces
  - Procedural e.g. how to ride a bike, grammatical understanding of a sentence, keyboard skills, swimming

Baddeley (2000)

Working memory

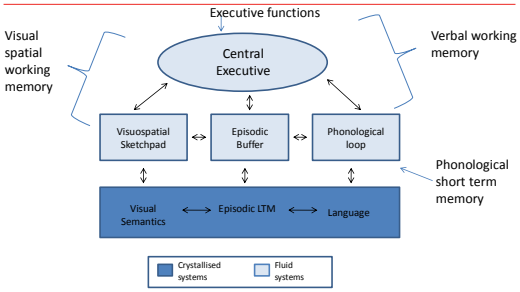
- Involves **processing** of information **stored** in long term and short term memory

NB. we use 'short term memory' for storage alone and 'working memory' for storage and processing.

- Closely linked to language processing are:
  - phonological short term memory
  - verbal working memory

Baddeley (2000)

Baddeley's model of working memory (2000)



Phonological short term memory

- Proposed to be a specialised memory system which sets up long term representations of phonological forms necessary for learning new vocabulary.
- Capacity of phonological loop
- Assessed through repeating increasingly long non-words e.g. "strimperdiction"
- Many studies have shown non-word repetition is an extremely sensitive test of past and current Language impairment (e.g. Bishop, North & Donlan, 1996)
- *Try out non-word repetition test*

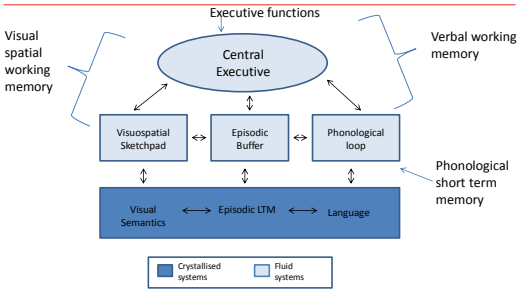
Research on PSTM and language

- WM span increases with development (Gathercole & Hitch, 1993)
- PSTM tends to be **poor** in children with SLI even relative to language matched peers (Gathercole and Baddeley, 1990).
- Higher PSTM associated with **higher vocabulary** and **syntax** in preschool years (Newbury et al., 2015 / in press; Chiat & Roy, 2008)
- PSTM associated with **better phonological awareness** and acquisition of decoding skills (Gillam & van Kleeck,1996)
- Specific acquired PSTM deficits associated with difficulties learning **foreign vocabulary** and **comprehension** of complex syntax (Baddeley, Papagno & Vallar, 1988)

Research on PSTM and language

- Strong evidence of PSTM involvement in learning **novel** phonological forms.
- The better you can recall a novel word form, the fewer repetitions of it you need before a strong representation is laid down in LTM and it has become part of your vocabulary.
- A **slow start to vocabulary** acquisition is common pattern seen in children with SLI.
- Children with resolved early vocabulary delays usually have a **shorter PSTM span** even once they have caught up with language (Bishop North, Donlan 1996).
- There is also some evidence to suggest PSTM is involved in the **acquisition of morpho-syntax** as well, a key deficit in SLI (Chiat and Roy, 2008).

Baddeley's model of working memory (2000)



Verbal working memory

- Proposed to involve both **storage** and **processing** of verbal information
- Assessed in listening span task e.g. child hears "pumpkins are purple (true / false); balls are round (true / false)" and then recalls the last word in both statements (Alloway, 2012; Tompkins et al., 1994)
- Children with SLI have consistently **shorter listening spans** for sentences than TD children. Most have shorter spans than language matched younger TD children. (Archibald & Gathercole, 2006)
- *Try out the working memory measure*

Verbal working memory

- VWM and language skills show a **strong association** in children with SLI and TD children.
- Evidence of VWM involvement in **sentence comprehension, inferences, metaphors, story generation, discourse skills.** The conscious processing of complex new language for the purposes of comprehension.
- Central executive is thought to be **weaker** in children with SLI.
- **Mixed evidence** of executive Function deficits in children with SLI – more common in those with a severe disorder.
- *VSWM shows some weaknesses in children with SLI due to involvement of the Central Executive but not the Visuospatial Skechpad.*

What impact could a low VWM span have on language ?

- Poorer comprehension of **complex grammar / discourse**
- **Fewer semantic links** between words
- Difficulty with **inferences**
- More **effortful processing** even of simple sentences e.g. SVO
- **Slower** academic learning
- More **difficulty correcting errors**
- More **difficulty processing multiple stream**s of input

(Zaretsky, 2004; Montgomery & Evans, 2009; Baddeley, 2010)

Can we separate WM and language for assessment purposes?

- If you are assessing verbal WM – by definition, **no**.
  - Can reduce semantic / syntactic processing demands so the linguistic demands are well within the ability of the child. The WM load increases as task progresses.
- If you are assessing PSTM – by definition, **no**.
  - You can reduce wordlikeness. Will always be a phonological task. Can keep the phonological demands within the ability of the child, so mainly the memory load increases as words get longer.
- Can more easily assess visual spatial working memory systems separately from language – but people may use language strategies

Investigation: Can working memory and language scores stand alone?

- Archibald & Joanisse (2009) tested 400 school-aged children on WM / Language / IQ tests
- They identified 6 subgroups of children
  - Language impairment only
  - Working memory impairment only
  - Language and working memory impairment
  - WM impairment in either verbal or visual spatial
  - L I and WM impairment in either verbal or visual spatial
  - No language / WM impairments

Implications from the study

- YES the subgroups tell us they dissociate
- It also casts doubt that poor WM is a **causal factor** in Language Impairment
- The correlations between WM and language are **strong** but are **not perfect**
  - Poor working memory alone is insufficient to cause a language impairment. Also it is not necessary as children can have a LI without a WM impairment. (Bishop, 2006)
- There must be **other factors** which affect language and working memory abilities
  - E.g. Processing speed, procedural memory, auditory processing

Assessing Working Memory

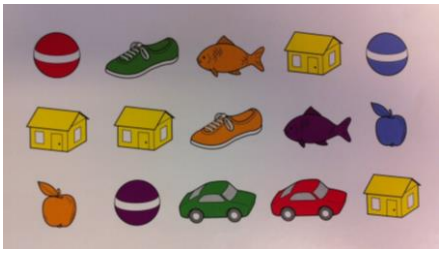
- WM tests which SLTs with a bachelor's level qualification can use:
  - CELF-4 (Semel, Wiig & Secord, 2006) subtests – Memory Composite includes span tasks
  - Automated Working Memory Assessment II (Alloway, 2012)
  - Working Memory Rating Scale (Alloway, Gathercole & Kirkwood, 2008)

Postgraduate qualification:

- Working Memory Test Battery for Children (Gathercole & Pickering, 2001)

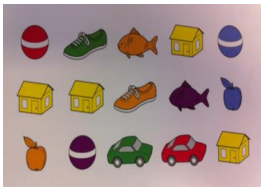
Example from Concepts and Directions (CELF4)

- Point to the house in the top row



Example from Concepts and Directions (CELF4)

- PSTM / VWM
- Linguistic system
  - Semantics
  - Syntax
- Visual spatial
- Episodic buffer
- Pointing
- *Relies more on verbal memory and linguistic understanding*



Recalling sentences (CELF4)

- Repeat after me:
  - "The van was preceded by the ambulance"
  - No visual stimuli
  - No repetitions allowed
  - No processing per se required, just a repetition, however studies show that people do process the meaning automatically and if they can't recall the sequence of words perfectly, recreate a new sentence with similar meaning
  - PSTM and linguistic system
  - *SR – measures primarily linguistic system*

Comments on sentence repetition

- Either delayed or immediate repetition
- Proposed as a clinical marker of SLI
- Klem et al., (2015) reported results of a longitudinal study looking at interrelationships between language, WM, and sentence repetition.
  - Concluded that SR is best seen as a measure of **underlying language ability** rather than memory
  - Useful for lang ax as it draws on a wide range of **language processing skills**

Implications for assessment

- Consider the WM **demands** of the tasks given
- Sentence repetition taps both STM and core language skills in LTM
- Consider the **visual support** available in subtests as this reduces the load on WM
- Consider how **familiar the vocabulary** is, as this reduced the load on WM
- **However be cautious in simple interpretations**
- CELF-5 has WM subtest – refer for further cognitive testing if difficulties noted. Don't interpret it.

Take home point:
Don't try to separate WM and language entirely – they work together as an integrated system. However some students have a more marked difficulty with one or the other.

Case 1 -

- WD age 8 years 1 month (male)
- TONI score 109

Memory Tests	Non-Word Repetition	Listening Span
Standard scores	80	76

Language Test	Core Language Scale	Concepts and Directions	Word Structure	Recalling Sentences	Formulated Sentences
Standard score	81	10	4	7	6

Standard scores have a mean of 100 (10) and standard deviation of 15 (1.5)

Case 2 -

- HB 8 years old, female
- TONI score 87

Memory Tests	Non-Word Repetition	Listening Span
Standard scores	92	101

Language Test	Core Language Scale	Concepts and Directions	Word Structure	Recalling Sentences	Formulated Sentences
Standard score	69	4	5	4	6

Investigation: What do mild LI / mild – mod WM difficulties look like in class?

- Archibald, Joanisse & Edmunds (2011)
  - **Children with SLI / SWMI / both presented similarly in class**
  - Teachers perceived their behaviour mainly as difficulties with **attention, language and behaviour**
  - Children with WM difficulty were reported to have **difficulty with language** (e.g. needing more explanations) children with language difficulties were reported to **have difficulty with memory**
  - Having difficulties in both did not double their problems in class – mainly presented as an LI

Commonly reported behaviours of children with WM / LI

- inattention
- failure to monitor the quality of work
- lack of creativity in problem solving
- speaking over others
- needing instructions repeated
- incorrect / inadequate answer to question
- careless mistakes
- does not wait for turn
- miscommunications…

Application to your caseload

- Consider a child on your caseload whom you know/ suspect has working memory difficulties:
  - What assessments have been done to confirm this?
  - Would confirmation of WM or other cognitive difficulties through assessment by yourself or a psychologist be helpful?
  - What intervention supports can be / have been offered to this child to either compensate or improve his/her WM limitations?

Implications for WM intervention

- Children often asked to store a **considerable amount of information** and then **act on it** in class
- **Task performance** = capacity limits, knowledge representation and strategy use
- How are tasks **communicated**, how is information delivered?
- What **increases** WM demands? – new concepts, new vocabulary, less visual support, complex sentences, limited time to process

Implications for WM intervention Cont.

Example tasks:
Following instructions; writing tasks especially when new for the student; paragraph comprehension; reading comprehension; mental calculations for math e.g. word problems.

General rule of thumb – one new thing at a time.

- *If vocab is new, keep syntax simple.*
- *If concepts are new, use familiar vocabulary to explain it.*
- *Complex sentences have the best chance of being understood once the vocabulary and concepts are familiar.*

WM Intervention options

- Reduce the impairment
  - Working memory training (commercial programmes)
  - Language intervention which incorporates increasing demands on working memory in the task
- Compensation
  - Strategy use to reduce the impact of the working memory difficulty
  - Information given to child / family / teachers

Key WM compensatory strategies – *students' role*

- Improve **metacognition** and use of **strategies**
  - Teach children to reflect on the task and what they can do to help themselves
  - Suitable for older children e.g. 9+
  - Students with LLD less likely to use strategies than TD children even when taught
- Examples
  - Rehearsal strategies – chunk, repeat
  - Task analysis - steps needed
  - Visualise –following instructions, or overloading for some
  - Study / organisation skills – make a study plan

Key WM compensatory strategies – teacher or whānau role

- **Repetition**
- **Chunking** – pause and summarise
- Biggest hurdle is **starting** the task
- Ask student to **repeat** to you what you said
- **Slow** down rate of speech
- Do **one part** of task then come back

Key WM compensatory strategies – teacher or whānau role

- In **group** discussions, ask child with poor WM to contribute **1st** rather than 3rd or 4th
- Present information **visually**
  - Graphs, charts, schedules, written instructions, diagrams,
- **Pre-teach** information
- Increase **automaticity** of skills

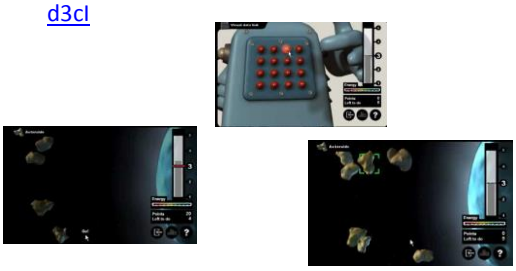
Working memory training

- Recent surge in working memory / cognitive training programmes available commercially online e.g. CogMed/ Jungle Memory / Lumosity
- concept of neuroplasticity
- Part of the search to remediate cognitive disorders
- Huge public interest and appeal
- Multi-million dollar industry

Luminosity quick look

A closer look at CogMed

- https://www.youtube.com/watch?v=vUYWF1xd3cI



Excerpt of research summary from CogMed website:

- States the following claims are supported by evidence:
  - **CM results in sustained improvements (2-12 mo) in WM from children – adults (30 studies)**
    - NB most outcome measures similar to training tasks
    - NB improvements in visual more common than verbal memory
  - **Learning outcomes in reading / math for some but not all students**
    - NB WM only one factor in academic success; might be cumulated benefits over time
- Acknowledges that WM is easy to measure in laboratory situations but not in everyday life – this limits the research base

Soderqvist & Nutley (2016)

Holmes et al. (2015)

- The only study published so far on WM training with children with LI
- Used Cogmed
- Compared 8-11 yr old TD children (n=15) / children with LI (n=12)
- Both groups showed minimal gains in verbal memory except better NWR at 5 syllable level in LI group
- Both groups showed significant gains in VSSTM
- Those with lower verbal IQ initially made more gains in verbal memory and VSSTM
- Concluded that WM training may be useful for some children with LI

Independent systematic / meta-analysis reviews

- None of these reviews below found the evidence presented by Cogmed to be convincing e.g.
  - The effect size confidence intervals accumulated across the highest level studies crossed zero
  - They queried the value of training the test
  - Subjective bias in teacher / parent questionnaires
- They concluded the evidence so far is unconvincing that Cogmed improves WM or attention or that it transfers to academic outcomes.
- WM training is a work in progress

Hulme & Melby-Lervag (2012)
Shipsted, Randall and Engle (2012)
Redick et al. (2015)

Our thoughts on CogMed

- Cost around $1500 for 5 week training
- Can be done alongside mainstream schooling
- Training tasks are not very similar to functional everyday activities
- Likely to result in child getting better at tasks trained
- May have a positive psychological effect e.g. child believes they can learn, attend better, succeed?
- Money probably better invested in individual tutoring in reading / maths / language i.e. functional practice at meaningful tasks at the child's level
- Fundamentally this is a parent decision

Summary/Recap

- Revision of working memory
- WM and language work together as an integrated system.
- Revision of what language assessments tell us about working memory
- Compensatory and intervention ideas discussed for working memory
  - A language intervention approach will target WM and language
  - A working memory approach targets the tasks worked on

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